California MEDICINE

OFFICIAL JOURNAL OF THE CALIFORNIA MEDICAL ASSOCIATION

VOL. 69 SEPTEMBER, 1948 No. 3

The Response of Articular Cartilage to Trauma

With Special Reference to the Knee Joint

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TRAUMATIC and degenerative changes in the articular cartilages have often been overlooked and emphasis has been placed upon injuries to the bones because the roentgenogram clearly demonstrates the latter lesions but gives little clue to the state of the cartilage. The surgeon is impressed by the degree of alteration seen in the cartilage of the exposed joint, the roentgenogram of which has been normal. It is these articular lesions which are often the greatest cause of disability, particularly following fractures which occur in the vicinity of joints. They may also be a cause of prolonged disability following contusions and sprains. The high frequency of such a condition as chondromalacia of the patella in minor injuries of the knee is well indicated by a study of 289 consecutive arthrotomies of the knee, made in three separate military hospitals.[7] In this series, 10 per cent showed degenerative changes in the articular surface of the patella.

King[4] has shown experimentally in dogs that such changes occur in the articular surfaces of the knee three or four months after the excision of a part of the medial semilunar cartilage. Other experimentation[5] has shown that the division of the medial collateral and crucial ligaments, by allowing relaxation of the knee, will produce severe articular lesions. Such clinical and experimental observations explain the persistent symptoms which may follow the excision of a semilunar cartilage, or other arthrotomy of the knee. Similar lesions involving the cartilage of the lower end of the humerus often follow fractures of the head of the radius.

Articular cartilage is a highly specialized type of connective tissue which has the main function of providing a smooth gliding surface for the end or side of a bone. The method of nutrition of this cartilage is not clearly understood. Probably the basal layer of cartilage is supplied by the blood vessels of the underlying bone, whereas the more superficial cartilage cells are nourished chiefly by synovial fluid, since no capillaries can be demonstrated. This synovial fluid is probably diffused through the cartilage by the actual pressure and contact of the articular surfaces. Two hundred years ago the famous anatomist, William Hunter,[3] remarked, "If we consult the standard Chirurgical writers from Hippocrates down to the present age, we shall find, that an ulcerated cartilage is universally allowed to be a very troublesome disease; that it admits of a cure with more difficulty than a carious bone; and that, when destroyed, it is never recovered. Hildamus, in considering these diseases, has observed, that when the cartilages of a joint were destroyed the bones commonly threw out a cementing callus; and thus a boney anchylosis, or immovable continuity, was formed where the movable joint had been. So far as I have had opportunities of examining diseased joints, either after death or amputation, I have found, according to the nature and stage of the disease, the cartilages in some parts reddish and lax; or soft and spongie; or raised up in blisters from the bone; or quite eroded, and, perhaps, the extremities of the bones carious; or, lastly, a boney anchylosis formed. But I could never see, nor indeed hear of, the least appearance of an exfoliation from the surface of the cartilage." The same author described the circulus articuli vasculosus which is thought to supply nourishment to the peripheral portion of the articular cartilage through its perichondrium. It has been suggested[1] that this peripheral zone of cartilage has greater power to repair than the central area, a

Read before the Section on Industrial Medicine and Surgery at the 76th Annual Session of the California Medical Association in Los Angeles, April 30-May 3, 1947.

finding which we have frequently encountered in the patella. However, Shands[6] has failed to demonstrate this difference experimentally.

Because of the highly specialized nature of cartilage, there is very little power of regeneration. The response often varies with the depth and severity of the injury sustained. Damage to its superficial layers results in fibrillary changes which gradually extend in area and depth until a large area of chondromalacia is formed. Fractures and operative procedures which produce lesions extending entirely through the articular cartilage into subchondral bone are followed by a proliferation of connective tissues which, after a long period, undergoes metaplasia into a type of fibrocartilage which may provide a fairly satisfactory gliding surface. We have studied these reparative processes experimentally in rabbits by the production of closed fractures into joints and by the removal of small segments of articular cartilage and bone from the lateral condyle of the humerus.[2] The results of this work are in agreement with the observations of others to the effect that hyaline cartilage repairs injuries very slowly and incompletely through the formation of connective tissue which is gradually transformed into fibrocartilage and rarely into hyaline cartilage.

Another approach to this problem has included the microscopic study of surgical specimens from humans removed from 28 joints at various intervals following fractures which involved these joints.[2] This series included the head of the radius (five cases), carpal navicular (five cases), carpal lunate (four cases) and femoral condyle (three cases). Here also one observes little if any regeneration of articular cartilage following injury although the underlying bone heals quite rapidly. Figure 1 shows a microscopic section of a part of the articular surface of a navicular bone which was excised one year after sustaining a fracture which did not unite. The complete absence of any effort at repair is seen in the cleft which extends through all layers of articular cartilage but does not, in this area, continue into the subchondral bone.

The main lesions which are found clinically to involve cartilage are the following:

1. Chondromalacia,[8] which is most often seen in the patella but which may also occur in the femoral condyle and in the capitellum of the humerus. It is found after minor injuries such as strains and contusions. Its appearance some weeks or months after the injury suggests that it is associated with some impairment of nutrition of the cartilage. Although this condition may occur at any age it is more prevalent in young people. Certain individuals seem predisposed to its development. Another cause of chondromalacia is an instability or subluxation of the patella which subjects the knee joint to repeated minor traumata.

2. Osteochondritis dissecans, a condition which may be due to the occlusion of a terminal artery in subchondral bone, and which is often found in young individuals.

3. Degeneration of articular cartilage which is secondary to such internal derangements as tears of the semilunar cartilages, osteochondritis dissecans or osteochondromatous loose bodies.

4. Fractures extending into a joint.

5. Aseptic necrosis as is seen most often in the head of a femur following fracture (Figure 2) and in the proximal fragment of a fractured carpal navicular.

6. Degenerative changes in cartilage resulting from improper weight bearing which may be seen in overweight individuals with genu valgum.

The underlying causes of articular degeneration can be divided into five main groups:

1. Impairment of blood supply. This is the ob-

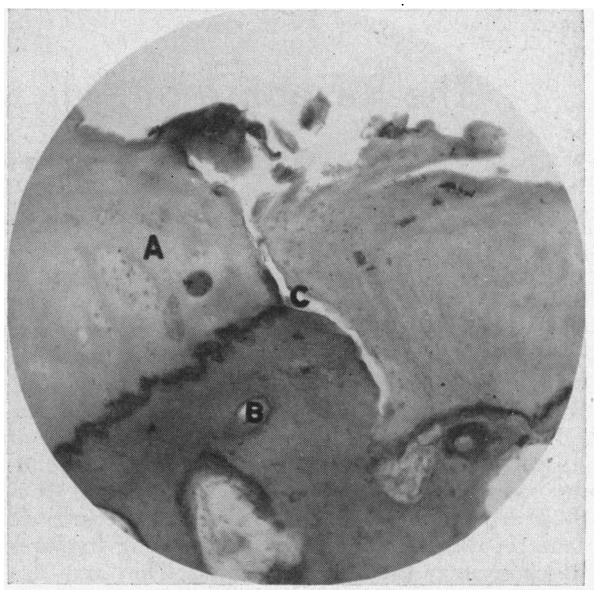

Figure 1.—Chondral fracture of carpal navicular 1 year after injury. A. Articular cartilage. B. Subchondral bone. C. Cleft in cartilage.

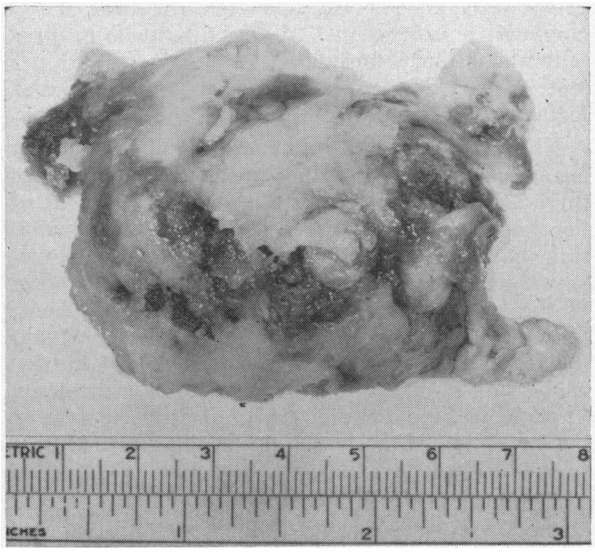

Figure 2.—Articular surface of head of femur which has undergone aseptic necrosis following fracture of femoral neck.

vious cause of avascular or aseptic necrosis and the probable cause of osteochondritis dissecans.

2. Damage to the basal layer of cartilage as seen in complete fractures or in osteochondral fractures.

3. Friction of irregular opposing joint surfaces. This factor comes into play with improper reduction of a fracture or in a lesion of an articular surface which results in a similar degenerative area in the opposing surface. This is well illustrated by the "mirror image" lesions of the femoral condyle following chondromalacia of the patella. Figure 3 shows an example of osteochondral fracture of the patella with detachment of about one-half of its articular surface and the production of a similar area of destruction in the opposing femoral condyle. The normal pressure and gliding mechanism of each surface is necessary for the health and nutrition of the opposite side.

4. Failure of functional contact of the articular surface. This is seen in unreduced dislocations of the head of the humerus or radius. In such cases, with varying degrees of rapidity, there is a progressive loss of the smooth articular surface which becomes pitted or may be invaded by connective tissue. The occasional speed of this process emphasizes the seriousness of delay in the reduction of a dislocation and the futility of the attempt to obtain a normal joint in a dislocation of long duration.

5. The large group of arthritis of pyogenic or rheumatoid origin is mentioned for the sake of completeness but is not covered in this presentation.

Prevention was never of greater importance than in the handling of injuries to articular cartilage. Such prevention depends upon early diagnosis and operative treatment of internal derangements of joints. A long period of hesitation or conservative treatment in the presence of an obvious loose body or tear of a semilunar cartilage often leads to secondary changes in the articular surfaces which produce residual symptoms and even permanent disability. Thus, decision as to operation must not be delayed too long. Any deformity of the weight-bearing axis, either developmental or traumatic, must be corrected to avoid improper stresses on joints. Overweight often leads to increased joint trauma, particularly in the knee. The role of the chronically subluxating patella in the causation of lesions of the femoral condyle should be recognized. This condition should be corrected, as an unstable patella will lead, after a number of years, to a disabling patello-femoral arthritis.

During operation special care should be taken to avoid any trauma to articular surfaces such as might be caused by the careless use of retractors or sponges. The rapid restoration of function by early postoperative mobilization of joints is good insurance against prolonged disability. During the period of splinting of joints, functional treatment by quadriceps setting exercises or by free movement of the fingers is indicated in order to preserve circulation and the free movement of tendons in the region of the articulation and to prevent atrophy of muscles. This explains the good results which are obtained in Colles fractures and other injuries when activity of the adjacent muscles is maintained throughout the period of immobilization.

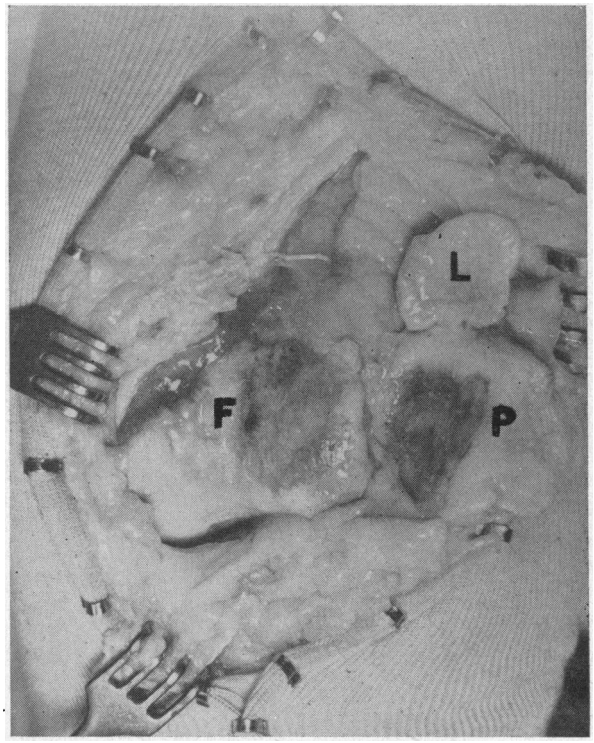

Figure 3.—Operative exposure of knee joint in which an osteochondral fracture of the patella has resulted in the detachment of a loose body of cartilage, and in the formation of a mirror image lesion in the femoral condyle. P. Patella. L. Loose Body. F. Articular surface of femur.

From what has been said it is obvious that a major factor in the prevention of prolonged or permanent disability is the perfect reduction of fractures which involve joint surfaces. No percentage of error is allowable as any irregularity leads to chronic irritation and permanent damage. It is for this reason that articular fractures in such weight bearing joints as the ankle, with its close fitting mortise, frequently are best treated by open reduction, perfect apposition and internal fixation of the fragments.

Although at operation on a chronically disabled joint one may be amazed by an advanced degeneration of its cartilage, he should not lose hope of being able to better the condition, for in some cases brilliant results in relieving pain and increasing function are attained. Magnuson,[5] describing joint debridement, has shown that the removal of exostoses and involved cartilage, accompanied in some instances by partial synovectomy, has brought about a great improvement in the function of joints. We have used this operation frequently and, in the presence of exposed subchondral bone, have in addition placed multiple drill holes in the sclerotic part of the bone in the hope of encouraging the formation of granulation tissue which should eventually be converted into a type of fibrocartilage. In certain circumstances it is possible to eliminate pain by the removal of one of the components of a damaged joint. Examples of

such instances include the excisions of the patella, head of the radius, outer end of the clavicle and lower end of the ulna. All of these procedures have had adequate trial and offer a great help in correcting these mechanical derangements of joints.

Finally, in weight bearing joints, when such conservative procedures as those described above are not feasible, and in cases of extensive degeneration, arthroplasty or arthrodesis is available. These two procedures have definite application and should be chosen with great care with regard to the ultimate function of the part. An arthroplasty is often entirely adequate in those individuals employed in sedentary and clerical work, whereas in those employed in more laborious ocupations, an arthrodesis will be more satisfactory.

SUMMARY

Hyaline cartilage is a highly specialized connective tissue with very little power of regeneration. An understanding of its response to injury explains many of the disabilities which follow trauma. Lesions of articular cartilage are amenable to surgical treatment with a high proportion of good results.

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